A Novel System for Analysis of Surface Profiles from 3-D Components Using the Dickinson Rotating Ring Contact Profiler

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ABSTRACT

In this paper the authors present a novel system, the Dickinson Rotating Ring Contact Profiler (DRRCP) for measuring the surface profiles of components with ring profiles. Race car piston rings have been used as a test case to prove the simplicity and validity of the new system. The results obtained from the DRRCP were compared with the standard system and similar values of the mean and standard deviation were obtained, $Ra = 0.3 \pm 0.05$ and $Rz = 0.6 \pm 0.09$ respectively. The system is readily adaptable to other cylindrical components and is predicted to have further applications in other fields/systems.

Keywords: 3-D Components, Dickinson Rotating Ring Contact Profiler (DRRCP), Piston Ring, Race Pistons, Surface Profiles

1. INTRODUCTION

Surface profilometry is a common method used in the analysis of surface roughness, shape and waveness of engineering components (Tanner, 1979; Weightman & Light, 1986). The analysis involves measurement in high resolution along the lateral and vertical axis. It is well known that the performance and life of engineering components is highly dependent on the surface properties (Yip et al., 2003). For example, wear rates are considerable greater in rough surface compared to smooth surface and components engineered to have a smooth surface have longer lifetimes (Khanna et al., 1999). There are a number of methods for measuring the surface roughness of components including optical techniques such as classical interferometry,
holographic interferometry, speckle techniques and white light interferometry (Lu et al., 2007; Norskov, 1984; Stewart et al., 2002) as well as mechanical techniques (Cockeram & Wilson, 2001). In this paper we focus employing the Taylor Hobson Talysurf for measuring surface roughness (Bacchetta et al., 1997; Cockeram & Wilson, 2001; Kasai et al., 1994; Kimura et al., 1998). This instrument employs a mechanical transducer known as the stylus which moves across the x-axis of the surface of a component and its vertical movement is recorded to obtain the surface profile. One of the major disadvantages of this method is that it is restricted to horizontal substrates and therefore to obtain profiles of 3-D components such as piston liner to ring contact face is problematic. In this paper we present the design, manufacture and application of a new piston ring mounting system for use in the analysis of surface profiles of the complete piston ring component. The new system is employed in conjunction with the Taylor Hobson Surface Profilometer in order to ease the measurement of 3-D components which are ring shaped. The data obtained will give a greater insight into the causes of wear and performance of piston rings in racing engine.

2. EXPERIMENTAL

2.1. Surface Profilometer

The Taylor Hobson instrument employs the movement of a 90o conical diamond stylus with a spherical tip in the range of 6mm which is carried at one end of a beam pivoted at the fulcrum on knife edges. The remote end carries an armature which moves between a pair of coils altering their relative inductance. Special gauges are employed to amplify the signal increasing the resolution ratio from 1000:1 to 64000:1 allowing a 0.6nm resolution to be reached for a range of 0.03 mm in the z-direction with a maximum nominal measuring range of 0.8mm. The instrument has a length interval of 120 mm/0.1 mm (xmax/xmin). The data sampling interval is 0.25 mm for traverse length to 30 mm and 1 mm for length over 30 mm. The instrument is controlled by Ultra software incorporating calibration and measurement functions. For the roundness of a surface device, like the Talyrond has been employed. This instrument provides the operator with a spindle provided by the company. This allows for the precision profile testing having a large accuracy of less than 0.02um radial axial. The device also has a coning error of 0.0003um/mm (Tan & Ripin, 2011). The data points gathered from the instrument sample at an extremely high level of 18000 points. However the problem still posses with this device how can the piston ring be mounted and profile in its circular profile. Each roundness profilometer offer the same problem of “how can the piston ring be mounted into a position where the contact face can be checked.”

2.2. Standard Sample Holder Systems

The standard sample stage system comprises of a three base plates where the lower base plate is incorporated to allow for fixing to the machine. Figure 1 shows a schematic of all the components and Figure 2 is a photograph of the system. The mid plate is used to allow the adjustment plate the movement range of 20mm in the Y axis. The adjustment plate is positioned by a micrometer which is mounted to the front of the base plate. Between the two plates an inner rail and outer rail is mounted these rails allow the adjustment plate to be moved with ease. To allow for precession movements of the adjustment plate, two springs at each side of the adjustment plate are placed parallel with the micrometers which are held by two locator spring pins. For special project mounting holes are placed in the adjustment plate to allow for fixing into position.

2.3. New Piston Ring Mount System

To overcome the disadvantages of the standard sample holder system (Figure 1), a new piston ring mount system was designed, manufactured and tested in our research laboratories at the University of Central Lancashire (Figure 3 and
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